M. Hachette:
With Dr. Gregory's best Comps
(10)

AN

ORATION,

DELIVERED AT

The Anniversary

OF THE

PHILOSOPHICAL SOCIETY

OF

LONDON,

JUNE 12, 1817.

By OLINTHUS GREGORY, LL.D.

ONE OF THE VICE PRESIDENTS OF THE SOCIETY, HONORARY MEMBER OF THE LITERARY AND PHILOSOPHICAL SOCIETIES OF NEW YORK, AND OF NEWCASTLE UPON TYNE, OF THE NEWCASTLE ANTIQUARIAN SOCIETY, &c. &c. &c.

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1817.

TO

FIELD MARSHAL HIS ROYAL HIGHNESS

THE DUKE OF KENT AND STRATHEARN,

K.G. G.C.B G.C.H.

&c. &c. &c. &c.

HIS ROYAL HIGHNESS

THE DUKE OF SUSSEX, K.G.

&c. &c. &c. &c.

Patrons;

AND

THE RIGHT HONOURABLE

THE EARL OF CARYSFORT, K.P.

LL.D. F.R.S. F.A.S. M.R.I.A.

&c. &c. &c.

President;

THE FOLLOWING

ORATION,

DELIVERED

AT THE ANNIVERSARY MEETING

June 12, 1817,

IS HUMBLY INSCRIBED,

BY THEIR ROYAL HIGHNESSES

AND HIS LORDSHIP'S

MOST GRATEFUL AND OBEDIENT SERVANT,

OLINTHUS GREGORY.

Royal Military Academy, Woolwich,

June 19, 1817.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

ORATION,

&c. &c.

There is implanted in the minds of all men of an investigating turn, an inextinguishable desire to penetrate to the origin of things: and there can be no doubt that such a desire, properly regulated, and judiciously directed, may be productive of beneficial results. It may teach us at once the strength and the weakness of human reason; may prove that though the regions of knowledge are extensive, rich, indefinitely diversified, and incessantly augmenting, they are, notwithstanding, limited. In surveying the present and past state of science and art, it is extremely difficult to make such a separation between what *is* known, and what *was* known, as shall preserve us from imputing to mankind in any given place and period, erroneous measures either in kind or degree, of theoretical or practical acquisition. The obvious consequence is that we are too apt,

notwithstanding the utmost caution, to suppose them ignorant of matters which they well understood, or conversant with others with which they were unacquainted; to infer, in short, their knowledge from our own, to try *their* conduct by *our* standards, and thus, often to censure, where we ought to applaud.

If we attempt to pass to any of the extreme points, towards which the understanding is often solicitous of elevating itself, we shall find much that is delightful, not a little that is perplexing. Take for a topic of meditation, the *first* of any series, the first man,—the first woman,—the first ear of corn,—the first day,—the first night,—the first solar eclipse: examine it in itself, trace it in its relations, dependencies, and results,—and how soon will the most capacious intellect be lost in the speculation. Take, for example, the first man, endeavour to depict his thoughts or his feelings, on the first day or the first night, and you will find it exceedingly difficult, even if you can reach his probable conceptions, to select adequate language in which to describe them to others.

Our great poet, Milton, seems to have been aware of this difficulty; and in many parts of his matchless production, *Paradise Lost*, has evidently restrained his imagination for the purpose of avoiding those incongruities upon which he might otherwise have fallen. Yet, *he* has not escaped them, altogether. He fancies both the first man

and his angelic instructor to employ language, which is obviously inappropriate, insomuch as it implies an acquaintance with practices, customs, and ceremonies, which have only found place in a maturer state of the world.

Adam speaks of

> "The *pledge* of day, that *crown'st* the smiling morn:"
> "The sun" that "*paints* their fleecy skirts with *gold*."

Raphaël, in describing to him the order of creation, speaks of light being

> "Transplanted from her cloudy *shrine*, and plac'd
> In the sun's orb:"

of the

> "Great *palace* now of light:"

of the stars, which

> "In their *golden urns* draw light:"

of the morning planet, which

> "*Gilds* her horns:"

of the

> "Glorious *lamp*," seen in the east,
> "*Regent* of day."

And even in that exquisite passage, in which with such a noble mixture of genuine philosophy and touching poetry, there is an attempt

> "For man to tell how human life began:"

the whole is, in my judgment, faultless, at least in reference to this particular, till the new created mortal, tired with his own emotion, overwhelmed with his own delight,

> "On a green shady bank, profuse of flowers"
> Sits "pensive down;" where "gentle sleep

First found" him, and "with soft *oppression* seiz'd"
His "droused sense."

Who does not perceive in all this, that the poet, in spite of his obvious efforts to the contrary, blends the circumstances of the pristine state with those of the times in which *he* lived;—and thus makes the first man, while he was yet without progeny, and his celestial instructor, illustrate surrounding objects and the emotions they excite, by metaphors drawn from an acquaintance (to him impossible) with the arts, practices, institutions, benefits, and evils of polished society;—with pledges, substitutions, painting, gilding, lamps, urns, shrines, crowns, monarchs, regents, freedom, tyranny, and oppression? Be it observed, however, that I advert to these palpable incongruities, not with the intention of censuring this admirable poet, but of evincing the nature of the difficulty, which so powerful an intellect, so sublime a genius, as his, though fully conscious of it, was unable to surmount.

In tracing the progress of science, the difficulty is of a different kind. We are not so often at a loss, to ascertain what was early known with regard to any department of scientific research, or to describe it to others, when ascertained, as to mark the chronological steps in the series, to show the gradations by which it may have passed from its rude, or accidental, or imperfect origin, to the mature state in which we now behold it, and from which we are incessantly deriving so many advan-

tages. Much, it is true, has been done in this respect, but much more remains to be accomplished. The simile of a bridge of numerous arches, by which human life has been sometimes aptly illustrated by the moralists, might with a simple inversion be applicable to what is before us: *there* the whole of the bridge is seen, except its extremities, which are pictured as enveloped in clouds; *here* the extremities are illuminated, while mists and fogs hang over many portions of the intervening space. It may, however, be useful, especially to the younger votaries of philosophy, to fix the attention for a while upon the extremities which are most plainly marked,—to contrast the appearance of the early germ with that of the mature plant,—to meditate upon the astonishing difference between the first thought and the expanded series of deductions from it, between the naked, insulated propositions which were first educed, and the complete system of acknowledged verities, of which they at present form perhaps a very inconsiderable part. Such is the object to which I would now direct your attention: and, as I am unwilling to draw too largely upon your candour and forbearance, I shall endeavour to make appropriate selections; referring, for a fuller draught from so rich a stream, to the historians of science.

Allow me to commence with the subject of pure mathematics. Among its earliest promoters was the celebrated *Pythagoras*, author of the

appellation *philosopher*,* and "rendered immortal in the annals of geometry," say the historians, by the invention of the multiplication table, and by the discovery of three propositions, viz. That only three regular plane figures, the equilateral triangle, the square, and the hexagon, can fill up the space about a point. That the sum of the three angles of every plane triangle, is equal to two right angles. And, that in any right angled plane triangle, the square on the longest side, is equal to the sum of the squares on the two other sides. The discovery of this last proposition, excited in the mind of Pythagoras such ecstatic and devout feeling, that he is described as offering a hecatomb to the gods on account of it. This I am inclined to disbelieve, for the reason assigned by Cicero, "that it was

* While Pythagoras was at Phlias, Leon, the chief of the Phliasians, was exceedingly charmed with the ingenuity and eloquence with which he discoursed upon various topics, and enquired of him in what art he principally excelled: to which Pythagoras replied, that he did not profess himself *Master* of any art, but that he was a *philosopher*. Struck with the novelty of the term, Leon asked Pythagoras, who were philosophers, and in what they differed from other men. Pythagoras, in reply, observed that, as at the public games, whilst some are contending for glory, and others sell their wares in pursuit of gain, there is always a third class, who attend merely as spectators; so, in human life, amidst the various characters of men, there is a select number, who despise all other pursuits, and assiduously apply themselves to the study of nature and the search after wisdom; these, added Pythagoras, are the persons whom I call PHILOSOPHERS. Cic. Tuscul. Disp. lib. v. c. 3.

inconsistent with his principles, which forbad bloody sacrifices." But, if the story be, as is probable, a mere fiction, it still serves to mark the state of mathematical knowledge, when a proposition which, however fertile in its consequences, is now placed amongst the lowest elements, should be characterized as the most brilliant discovery of the great man to whom we owe it.

It does not comport with the nature of an address like the present, to contrast these in detail with the modern state of geometry, of algebra, of fluxions, of the trigonometrical analysis, of logarithms, and exponentials, of series, of rectifications, quadratures, cubatures, tangencies, points of contrary flexure; together with the sublime researches in the theories of isoperimeters, variations, and partial differences. Much less can I attempt to sketch the diversified applications of these to mixed mathematics, and the contributions which have thus been made to the arts and com modities of civilized life. On these topics it would, in truth, be delightful to expatiate, were it not that I should in consequence be compelled to exclude others on which I am desirous of presenting a few remarks. It will, however, be acknowledged by all competent judges, that the eulogium of Dr. Barrow, though elaborate is not extravagant, especially when applied to the investigations and discoveries of modern times. This great man, with the richness of expression which distinguished his scientific as well as his theological

productions, speaks of the mathematics as that "which effectually exercises, not vainly deludes, nor vexatiously torments studious minds with obscure subtleties, perplexed difficulties, or contentious disquisitions; which overcomes without opposition, triumphs without pomp, compels without force, and rules absolutely without causing the loss of liberty: which does not privately overreach a weak faith, but openly assaults an armed reason, obtains a total victory, and puts on inevitable chains;" "which plainly demonstrates and readily performs all things within its verge." "The mathematics, which depends upon principles clear to the mind, and agreeable to experience, and draws irresistible conclusions:" "Which is the fruitful parent of, I had almost said, all arts, the unshaken foundation of sciences, and the plentiful fountain of advantage to human affairs. In which last respect we may be said to receive from the mathematics the principal delights, securities, and conveniencies of life." To this it is principally owing as a theoretic spring of action and benefit, "that we dwell elegantly and commodiously, build convenient houses for ourselves, erect stately temples to God, and leave wonderful monuments to posterity:" "That we have safe traffic through the deceitful billows, pass in a direct road through the trackless ways of the sea, and arrive at the designed ports by the uncertain impulse of the winds: that we rightly cast up our accounts, dispose, tabulate, and calculate scattered

ranks of numbers, and easily compute them, though expressive of heaps of sand or mountains of atoms:—that we make pacific separations of the bounds of lands, examine the moments of weights in an equal balance, and distribute every one his own by a just measure:—that with a light touch we thrust forward ponderous bodies which way we will, and stop a huge resistance with a very small force:—that we accurately delineate the face of this terraqueous globe, and by diagrams subject the œconomy of the universe to our sight:—That we aptly digest the flowing series of time, distinguish what occurs by appropriate intervals; rightly predict and discern the various returns of the seasons, the stated periods of years and months, the alternate increments of days and nights, the doubtful limits of light and shadow, and the exact differences of hours and minutes:—that we derive the subtile virtue of the solar rays to our uses, infinitely extend the sphere of sight, enlarge the near appearances of things, bring to hand things remote, discover things hidden, search nature out of her concealments, and unfold her mysteries;" "freely range through the celestial fields, measure the magnitudes and determine the intervals of the stars, and trace the inviolable laws of their motions."*

From this inexhaustible general topic, let us descend to a few particulars drawn from several departments of science; taking first, that of the pressure and motion of liquids. Every one who

* Barrow, Prefatory Oration to his Mathematical Lectures.

hears me, will recollect the story of Archimedes's ecstasy when he discovered the principle by which might be detected the fraud of the goldsmith who made Hiero's crown. An accidental thought, suggested while he was bathing, led to the investigation of a series of propositions, enunciated and demonstrated in his two books "*De Insidentibus in fluido*" now extant. The nine propositions demonstrated in the first book, relate to the principal laws and circumstances of bodies floating on liquids, or sinking or rising in them; such as are now placed in the elementary enquiries respecting specific gravity. The second book comprizes ten propositions, serving to ascertain the different positions which would be assumed by a parabolic conoid in a liquid; according to the different relations of the axis to the parameter, and to those of the specific gravities of the conoid and the liquid. The strictness and elegance of the demonstrations accord with the highest conceptions that can be formed, of the powers of that extraordinary philosopher; but they relate to truths which now constitute the amusements of school-boys. Contrast them for a moment with the present state of Hydrostatics and Hydrodynamics; with the fine chain of researches which relate to the equilibrium and pressure of liquids and fluids, whether simple or mixed,—the stability of floating bodies,*—their motions and oscil-

* Among the investigations on this subject, so interesting to those who engage in naval architecture, it would be unjust not to mention, besides those of Bouguer, Euler, Atwood, and Juan,

lations when the equilibrium is disturbed,—the general principles which determine the operation of liquids in motion, or of liquids affected by solid bodies in motion—the operation of pumps,—the discharge of liquids through orifices in the bottoms or sides of vessels,—the motion of water in rivers, canals, open or closed pipes,—the construction of flood-gates, sluices, dams, and banks,—the oscillatory motion of liquids in syphons and other tubes,—the percussion and resistance of liquids, with their application to the motion of water-wheels of different kinds, to the structure and manœuvres of vessels and the entire practice of seamanship. How rich and diversified such enquiries, how vastly surpassing the discoveries of Archimedes * in hydrostatics, must be evident

those of M. *Charles Dupin,* a young French mathematician of considerable genius. His researches on the stability of vessels exhibit a singular union of the strictness of a geometer, the elegance of a classic, and the inventive fancy of a poet. Propositions which before required the attention of able mathematicians, are, through the ingenuity of this author, while they are accurately demonstrated, brought down to the comprehension of the *student.*

* It is evident from Archimedes's *Arenarius,* or treatise on the number of the sands, that the main property which he employed in his curious computations, is equivalent to that which was assumed as the fundamental property of logarithms. "If numbers (says he) are continually proportional, increasing from unity, and if two terms of such progression are multiplied together, the product will be a term of that progression, placed so many terms from the greatest factor, as the smallest is from unity: and this same product will be distant from unity, so many terms, less by one, as the two terms together are from unity." This property

even from this bare enumeration: but these, momentous as they are, sink much in grandeur and importance when compared with the sublime investigations of Laplace, in reference to the flux and reflux of the tides, and the stability of the equilibrium of the ocean. Although, in the indefinite variety of disturbances to which the ocean is liable, from the action of irregular causes, it may *appear* to return to its former state of equilibrium; yet, a theorist inclined to speculate and not qualified to investigate this profound subject thoroughly, may apprehend that "some extraordinary cause may communicate to it a shock which, though inconsiderable at its origin, may augment continually, and elevate it above the highest mountains." Now, Laplace by means of an elegant and refined analysis, has developed the conditions which are necessary for the absolute stability of the ocean. He has shown, irrefragably, "that the ocean is in a state of *stable* equilibrium: and if (as can scarcely be doubted) it has formerly covered continents which are now

slumbered 1850 years without being applied to any more extensive use, when it was seized by *Napier*, and extended, in his admirable invention of logarithms, to *all* numbers, whether they were terms of the assumed geometrical progression, or not. The mode of intercalation for all intermediate terms, constitutes at once the chief difficulty, and the principal excellency of Napier's invention. Far easier methods of accomplishing the same thing, are now known: but, under the disadvantages with which Napier must have had to contend, his success is at once a proof of the energy and the fertility of his genius. See Hutton's History of Logarithms.

elevated much above its level, the cause must be sought elsewhere than in the defect of its equilibrium. This analysis also shows, that this stability would cease to have place if the mean density of the sea *exceeded* that of the earth: so that the *stability of the equilibrium of the ocean, and the excess of the density of the terrestrial globe above that of the waters which cover it*, are reciprocally connected, the one with the other." *

What *we* term *accident* produced the train of thought in the mind of Archimedes which issued in the elegant though simple propositions contained in his work; and these again in the expanded series of verities to which we have so briefly adverted. But this is by no means the only case in which *accident* has opened to us an extensive field of instruction and delight. Whether it can be fairly inferred from some well known passages of *Seneca*, *Pliny*, and *Pisidas*,† that the ancients were acquainted with the power of glasses to magnify objects, or to make remote objects appear near; or, whether *Roger Bacon*, and the monks of his time, advanced farther than the construction of spectacles, are questions to which, however interesting they may be, we need

* Laplace, Exposition du Système du Monde, p. 266, 4to edition.

† Senec. Nat. Quæst. lib. i. cap. 6, 7. Plin. Nat. Hist. lib. v. cap. 20. lib. xxxvi. cap. 26. *Τα μελλοντα ως δια διοπτρȣ συ βλεπεις*, "you see things future, as by a *dioptrum*." Pisidas, as quoted by Junius.

not here devote any time. It suffices for my present purpose to remark that both *telescopes* and *microscopes* were unknown to the philosophers of the sixteenth century; and that a fortunate concurrence led to their invention, and to the grand and rapid extension given, in consequence, to the physical sciences. Borelli informs us, in a treatise composed not so long after the circumstance as to render his authority doubtful,* that the children of Zachariah Jansen, a spectacle-maker of Middleburgh, amusing themselves in their father's shop, placed by chance a convex and a concave lens in such a manner, that on looking through them at the weathercock of the church, it seemed to them nearer and much larger than usual. The father was called to witness this, and immediately fixing the glasses upon a board, that their relative position might be rendered permanent, he presented either those or others similarly arranged to his patron, Prince Maurice. The first telescope after these, which he made, was in the year 1590, and it did not exceed sixteen inches in length. No sooner was this remarkable discovery known than Galileo, Kepler, and other philosophers, bent the whole force of their genius to the improvement and employment of so useful an apparatus; and since that epoch, theoretical and practical men have vied with each other, in improving its construction and extending its powers. The possession of so noble an instrument, an eye which

* Borelli, De vero Telescopii inventore. Hagæ Com. 1655.

pierces to the regions of the stars, has given to astronomical researches a relish and a success unknown before. That "broad and ample road, the galaxy," has been ascertained to be, as the poet conjectured, "powder'd with stars." The faces of the moon and the planets furnish as much delight to the observer as the contemplation of the richest and most diversified landscape: the satellites which attend some of the planets in their course become discovered: the magnitudes, distances, orbits, and motions of the bodies constituting the solar system, become correctly appreciated; the greater accuracy of astronomical observations furnishes new employment for theorists; these again suggest new occupation for the observer; their joint labours tend to the perfection of modern astronomy, and theory and practice so illustrate, assist, and confirm each other, that some of the phænomena of the remotest bodies in the planetary system, computed *years* before their occurrence, are found, in the event, to happen *at the time specified*, to within the interval of *a clock's beat!* How exquisite a result of so simple an incident as boys playing with spectacle glasses in the shop of an illiterate mechanic!

Nor is this all. The same happy occurrence placed with analogous rapidity, in the hands of the natural historian, an instrument, the *microscope*, which has enabled him to explore, with equal delight and success, many of the minutest objects of creation, whose nature, properties, and uses,

might, otherwise, have been for ever concealed. The "wonders of the microscope," indeed, can scarcely be described without an appearance of hyperbole. I shall only venture upon one sketch of this kind; assuring you that though my author has not altogether restrained his imagination, his description, on the whole, accords with truth.

"The principal flower" (says he) "in this elegant bouquet was a carnation; the fragrance of this led me to enjoy it frequently and near; the sense of smelling was not the only one affected on these occasions; while that was satisfied with the powerful sweet, the ear was constantly attacked by an extremely soft but agreeable murmuring sound. It was easy to know that some animal within the covert, must be the musician, and that the little noise must come from some little body suited to produce it. I instantly distended the lower part of the flower, and, placing it in a full light, could discover troops of little insects frisking and capering with wild jollity among the narrow pedestals that supported its leaves, and the little threads that occupied its centre. What a fragrant world for their habitation! what a perfect security against all annoyance in the deep husk that surrounded their scene of action!—I was not cruel enough to pull out any one of them for examination; but adapting a microscope to take in, at one view, the whole base of the flower, I gave myself an opportunity of contemplating what they were about, and this for many days together,

without giving them the least disturbance. Thus could I discover their œconomy, their passions, and their enjoyments. With what adoration to the hand that gave being to these minute existences must a heart, capable of due warmth in his praise, see the happiness he has bestowed on them! The base of the flower extended itself under the leaves and became trunks of so many stately cedars; the threads in the middle seemed columns of massy structure, supporting at the top their several ornaments; and the narrow spaces between were enlarged into walks, parterres, and terraces. On the polished bottom of these, brighter than Parian marble, walked in pairs, alone, or in larger companies, the winged inhabitants; these from little dusky flies, (for such only the naked eye would have shown them) were raised to glorious glittering animals, stained with living purple, and with a glossy gold that would have made all the labours of the loom contemptible in comparison.—I could at leisure, as they walked together, admire their elegant limbs, their velvet shoulders, and their silken wings; their backs vying with the empyræan in its blue; and their eyes, each formed of a thousand others, out-glittering the little planes on a brilliant—above description, and too great almost for admiration."* How rich a treat for the lovers of nature! How little in the contemplation of Jansen's boys!

Every person competently acquainted with

* Sir John Hill: Inspector, No. 109.

English parochial customs, will be aware how long the force of steam must have been known, as evinced in the use of the village æolipile, distinguished by the name of "*Jack of Hilton.*" Yet this custom, though continued from time immemorial, seems not to have suggested any useful invention. While the Marquis of Worcester was a state prisoner in the Tower, some food being preparing on the fire of his apartment, the cover of the vessel, being tight, was, by the expansion of the steam, suddenly forced off, and driven up the chimney. This led him to a train of thought, in reference to the practical application of steam, as a first mover. The result of his speculations, obscurely exhibited in his "*Century of Inventions,*" successively wrought out by Newcomen and Cawley, Beighton, Boulton and Watt, and others, has at length terminated in that noblest example of mechanical ingenuity, as it now exists, —the Steam Engine. The whole operation of an engine of this kind, depends upon two principles, the developement of the elastic force of aqueous vapour by heat, and its sudden precipitation through the agency of cold, principles which are simple and well known. But the different expedients for the transmission of the force thus obtained, have greatly exercised mechanical ingenuity, and immensely augmented our stock of subordinate mechanism. No class of inventions has occasioned so entire a change in the construction and application of machinery as this;

none has tended more to facilitate and improve the main processes in arts and manufactures; and consequently, none has more contributed to the commercial ascendancy of Great Britain in the scale of nations. Yet all this flowed, in the first instance, from an incident to which one can hardly make a formal reference without exciting risible emotions.

Physical Astronomy, again, owes its origin to a simple incident. Sir Isaac Newton was forced from Cambridge in the year 1666 by the plague. During his retirement, says his friend Dr. Pemberton, as he was "sitting alone in a garden, some apples falling from a tree, led his thoughts to the subject of gravity." He was induced to conjecture that the moon was retained in her orbit by the same kind of force as that which caused the apples to descend to the earth, or that gave a curvilinear motion to bullets or other projectiles near the earth's surface. Ere long he made a computation upon this hypothesis, and found that the deviation of the moon, moving in her orbit, from the tangent at any given point, was precisely* what it ought to be, supposing the

* In Newton's first computation, being in the country, at a distance from his books, he took the common estimate (before Norwood's measurement) of 60 miles to a degree of the meridian, which not furnishing such a result for the deviation of the moon's orbit from its tangent, as he expected, led him for awhile to suspend his researches. But, when he became acquainted with the result of Picart's measurement, he went through the computation, with the data thus obtained, and then found, as stated in the text,

force of terrestrial gravity to vary inversely as the squares of the distances from the earth's centre. This step accomplished, it was not for such a mind as Newton's there to rest. He collected "from mathematical reasoning, unexceptionably demonstrated, that all bodies which are moved in any curve line described in a plane, and which, by a radius drawn to a point, either quiescent or moved in any manner, describe areas round that point proportional to the times, are urged by forces directed to that point. And, since it is agreed by astronomers that the primary planets describe about the sun, and the secondary planets describe about their primaries, areas proportional to their times; it follows, that the force by which they are continually deflected from the rectilinear tangents, and are made to revolve in curvilinear orbits, is directed towards bodies placed in the centres of those orbits. This force, from whatever cause it may be supposed to arise, he thought might not improperly be called *centripetal* with respect to the revolving body, *attractive* with respect to the central body." But he uses great caution (which I mention here, because I have heard very confident arguments against his philosophy, founded on a *mistake* as to this point) to prevent a misinterpretation of his meaning. "What I call *attraction* (says he) may

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that the deflection from the tangent was precisely such as his new hypothesis (for then it was simply an hypothesis) required.

be performed by impulse, or by some other means unknown to me. I use that word here to signify in general *any force by which bodies tend towards one another*, whatever be the cause. For we must learn from the phænomena of nature what bodies attract one another, and what are the laws and properties of the attraction, *before* we inquire the cause by which the attraction is performed." *

How immense and fertile the region of inquiry which was thus laid open to the world, I need scarcely hint to this assembly. Yet who can be entirely silent on so magnificent a theme? The earth, the sun, and all the celestial bodies which attend the sun, attract each other mutually. The minutest particles of each of them, and of all other bodies, conform to the same law: each particle acting proportionally to its quantity of matter directly, and to the squares of its distances from other particles reciprocally. Hence flow a variety, not yet, nor perhaps ever to be, exhausted, of interesting and important propositions. Such, for example, as those which relate to the attraction of spheres, spheroids, and other solids, whether homogeneous or not, upon particles in assigned positions;—the forces which retain the planets in their orbits so as to conform to the Keplerean laws;—the forces which disturb the elliptic motions of the planets and satellites;—the irregularities of the lunar motions and those of the other secondaries;—the mutations of the

* Newton's Opt. Query 31.

planes of the several orbits;—the figure of the earth and planets;—the variations of gravity at different points at their surfaces;—the tides;—the oscillations of the atmosphere;—the variations of atmospheric pressure at different altitudes;—the refraction of light while passing through the atmosphere;—the attractions of mountains;—the precession of the equinoxes, and the nutation of the earth's axis;—the irregular figure and balancing of Saturn's ring, and the dependence of that balancing upon that irregular figure;*—the libration of the moon;—these and many more topics of investigation springing from the theory of attraction, and each and all of them, as they are pursued, supplying greater or less confirmation of the existence, "the simple and sublime agency, of this commanding principle." By this principle, philosophers have, so to speak, decomposed the physical system of the world, reduced it to its single element, and then re-composed it. Viewed in this relation, physical astronomy is, unquestionably, of all the sciences, the most complete, the most sublime, and that in which the human intellect is most elevated. "But that which gives it, above all, an inestimable value, is its *perfect certainty*." Other branches of science have changed incessantly, and several must still undergo modifications, several perhaps be abandoned: yet, whatever be the progress of knowledge, whatever the expansion of intellect, the

* See Laplace. Exposition du Systéme du Monde, liv. iv. ch. 8.

principle of universal gravitation is established irrefragably, and the main deductions from it rest on an immoveable foundation. Hence it is, as Dr. Chalmers has finely remarked, that "when we look on the days" and discoveries "of Newton, we annex a kind of mysterious greatness to him, who, by the pure force of his understanding, rose to such a gigantic elevation above the level of ordinary men—and the kings and warriors of other days sink into insignificance around him—and he, at this moment, stands forth to the public eye, in a prouder array of glory than circles the memory of all the men of former generations—and, while all the vulgar grandeur of other days is now mouldering in forgetfulness, the achievements of our great physical astronomer are still fresh in the veneration of his countrymen; and they *carry him forward on the stream of time with a reputation ever gathering, and the triumphs of a distinction that will never die!*"*

Before I quit this subject, I shall, I trust, be pardoned, if I venture upon one more observation. It has been demonstrated by Lagrange and Laplace, that *all the planetary inequalities are* PERIODICAL, *each returning after a certain time, to go through the same series of changes which it had formerly exhibited;* the whole system oscil-

* See a most splendid eulogy on the distinguishing qualities of Newton as a philosopher, in the second of Dr. Chalmers's "Discourses on the Christian Religion viewed in connection with the Modern Astronomy."

lating, as it were, between certain limits which it can never pass. Now, this property, so essential to the well-being of the inhabitants of the several planets, requires the concurrence of these four, independent, conditions:—that the force shall be inversely as the square of the distance,—that the masses of the revolving bodies be small, compared with that of the central body,—that the eccentricities of the orbits be inconsiderable,—and that the planes of those orbits be originally not much inclined to each other. The irresistible conclusion thus furnished is, that *all this is the work of intelligence and design, for a benevolent purpose;* the work of a controlling and regulating Power, from whom all the powers of material nature emanate.

I might now pass to *Voltaism*, and shew, from the testimony of Biot,* Galvani,† and Haüy,‡ that this new branch of science, (a branch which, under the culture of Davy and others, has been made to contribute largely to our store of chemical facts and doctrines) may be traced to what Bacon terms "the *fortune* of experiment." But, lest I should far o'erstep the natural bounds of an oral disquisition, I must satisfy myself with this mere allusion, and proceed to my last selection.

In *Physiology*, as in physics, we have, occa-

* Biot, Essai sur l'Histoire générale des Sciences, p. 19.

† Aloysii Galvani, de viribus electricit in motu musculari commentar. p. 2.

‡ Haüy, Nat. Phil. vol. ii.

sionally, been more indebted to accident, to a happy, though perhaps at first an erroneous thought, than to the profoundest study, or the best conducted train of experiments. One of the most curious, as well as of the most important functions of the animal œconomy, is that of *digestion*, the real nature of which was only hit upon in this manner. Considering the comparatively slender texture of the stomach, and the toughness and solidity of the substances it is capable of digesting, it cannot appear surprising that mankind should have indulged in a variety of theories, and run into a variety of errors, in accounting for its mode of action. Empedocles and Hippocrates ascribed the process to a power, possessed by the stomach, of decomposing the food by a rapid putrefaction: Galen, to its decomposing it by a peculiar accumulation of heat, during the time of digestion: and Macbride and Pringle, long afterwards, to the action of fermentation; thus uniting the two causes assigned by the Greek writers. Grew and Santarelli embraced the doctrine of a concoction, by the various juices that are poured into the stomach from the liver, the spleen, and other organs; while Pitcairn, and all the mechanical physiologists, contended that it was accomplished by a process of trituration, produced by an enormous mechanical pressure of the muscular coat of the stomach upon its alimentary contents, which

they were fanciful enough to calculate (as I am assured by a learned friend* who leads me through this labyrinth) to act with a force exceeding 117,000 *pounds*, assisted at the same time in its gigantic labour, *by an equal force* derived from the surrounding muscles.

Reflecting men, however, were still dissatisfied. Each of these theories was found to be encumbered with difficulties of its own, while all of them were alike incompetent to explain the fact for which they were invented. At this moment Cheselden threw out the fortunate hint that possibly the process of digestion might be accomplished by some peculiar solvent secreted by one or other of the digestive organs: and he directly pitched upon the saliva, or the fluid secreted by the salivary glands. The hint was eagerly seized, and elaborately followed up by Haller, Reaumur, Spallanzani, and various others; and, though Cheselden was under a mistake as to the particular fluid, yet a fluid of a most wonderful solvent power was soon detected, secreted from the internal surface of the stomach itself, and its singular properties were satisfactorily ascertained and established.

This extraordinary menstruum, the most active with which we are acquainted in nature, is now well known by the name of *gastric juice*, so called from the Greek term for the organ that pours it

* John Mason Good, Esq. F. R. S.

forth.* Its apparent simplicity of composition is as remarkable as its digestive power: for, in a pure and healthy state, it is a thin, transparent, and uninflammable fluid, of a weak saline taste, and utterly destitute of smell. Its antiputrescent property is of as extraordinary a nature as its digestive: for it will render perfectly sweet the most offensive and putrid food that gipsies, or hungry dogs can be made to swallow, in about half an hour after such food has been exposed to its action. This gastric juice farther possesses, in an equal degree, both these curious powers of dissolution and restoration to sweetness, as well out of the body as in the stomach itself.

How majestically quiet and easy is the common walk of Nature! (employing the term in its usual acceptation as "a name for an effect whose cause is God")—how simple are the means she makes use of!—how wonderful in their operation!—how adequate to the end proposed! Measuring her, as we too often do, by our own imperfect powers, we take it at once for granted, that that which is to us elaborate, must be equally difficult to herself: in tracing her we are apt to overlook the principle of simplicity which is stamped on all her footsteps; we surround ourselves with a world of

* Even the stomach itself, when deprived of vitality, has been found acted upon, and, in a manner, *digested* by it. See John Hunter, *on digestion of the stomach after death*. Phil. Trans. vol. lxii. Or, J. Hunter's Observations on the Animal Œconomy, in which this paper is reprinted.

machinery, and lose our aim by the mere multiplicity of our agencies; till accident, in a lucky hour, suggests to us a new and easier track, on entering which we are equally surprised at our own dulness, and at the wisdom that beams before us.

But it is more than time that I should conclude. We have seen in the principal cases which I have selected, how much has sprung from *apparent* accident: I shall scarcely expect to be forgiven by *this* assembly, if I omit to add, that it was only accident in *appearance*. How many thousand persons had seen an apple fall, before Newton, with respect to whom the observation had been altogether unproductive? Besides the event of the falling apple, there needed the simultaneous operation of various independent causes to render it an epoch in the history of philosophy. It was necessary that it should be observed by a man at *leisure* to pursue any train of reflection that should thereby be suggested: it was necessary that it should be noticed by a man of *research*, and that—not as a lawyer,—not as a theologian,—not as an anatomist, a botanist, an entomologist, or a chemist, but as *a mathematical philosopher*. It was farther necessary that the observer should have a certain fund of previous knowledge, and yet, that his mind should not be *pre-occupied*. Had the falling apple been observed by Newton when he was absorbed in his admirable investigations concerning light and colours, it

might no more have led to the theory of Universal Attraction and the perfection of Physical Astronomy, than it would in the contemplation of the most illiterate porter that paces the streets of this metropolis. Let us view these matters aright. It is not chance, but previous design, that in this and other similar instances, brings so many independent circumstances into juxta-position; just as in the case of two travellers,—one passing from London northwards, the other from York southwards—meeting on the way, the *accident* of their meeting is a necessary consequence of the previous *determinations* of both to start at a certain time, and to travel by the same road.

The practical inference we may draw from the whole, and which I would strongly urge upon the younger part of my auditory, is simply this:—Do not *hastily* relinquish a train of thought, suggested by a fresh class of circumstances, even though the prospect of utility be very remote. If the poet spake truly that "our thoughts are *heard* in heaven," may not a philosopher remark with equal truth, that our noblest thoughts are *suggested* in heaven, and that all genius is a species of inspiration? Among the ancients, when nature was not, as too frequently happens among us, concealed under a thick veil of elucidation, this was unhesitatingly admitted; as by *Plato*, by *Phædrus*, and even by *Longinus*, the most reserved of ancient critics. They distinguished accurately the enthusiasm or inspiration of genius, from the

perturbed suggestions of the Θεόληπτοι and Phrenetici; but sought the occasion of both *ab extra*, and not in the imagination itself. In the latter case, they regarded the bark as driven of *necessity*, wanting cable and anchor to hold her; in the former, as sailing from *choice*, because the gale is from a favourable quarter, and the voyage desirable. Under another metaphor they viewed the imagination of the poet, and in its kind and degree, that of every man of genius, as *a field* in which the Author of Nature produces a set of objects which existed not before; as a region in which new images and combinations arise, like new plants, under auspicious circumstances of culture or climate, according to the settled laws of the Creator. So fruitful is the womb of Nature! So true is it, that we are all, more or less, the children of circumstances; and it behoves us, therefore, to avail ourselves to the utmost of the circumstances into which we are thrown. Distinguish, then, sedulously between the dictates of wisdom and of folly, the suggestions of reason and of fancy; but do not abandon a train of inquiry, merely because it seems likely to produce but *little*.* Remember that lofty trees grow from

* "Les applications du thermomètre dans la physique, la chimie et les autres sciences naturelles sont innombrables. Les indications qu'il nous donne sont la base de toute la théorie de la chaleur; il est le régulateur de toutes les opérations chimiques; l'astronome le consulte à chaque instant dans ses observations, pour calculer les déviations que les rayons lumineux émanés des astres

diminutive seeds; copious rivers flow from small fountains; slender wires often sustain ponderous weights; injury to the smallest nerves may occasion the acutest sensations; the derangement of the least wheel or pivot may render useless the greatest machine of which it is a part; an immense crop of errors may spring from the least root of falsehood; a glorious intellectual light may be kindled by the minutest sparks of truth; and *every principle is more diffusive and operative by reason of its intrinsic energy than of its magnitude.*

And let me entreat you, above all things, to avoid the great error of "mistaking or misplacing the ultimate object of knowledge." For many,

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éprouvent en traversant l'atmosphère, qui les brise et les courbe plus ou moins, selon sa température. C'est encore au thermomètre que nous devons toutes les connoissances que nous avons sur la chaleur animale, produite et entretenue par la respiration. C'est lui qui fixe dans chaque lieu la température moyenne de la terre et du climat; qui nous montre la chaleur terrestre constante dans chaque lieu, mais diminuent d'intensité depuis l'équateur, jusqu'aux pâles constamment glacés; c'est encore lui qui nous apprend que la chaleur décroît à mesure que l'on s'élève dans l'atmosphère, vers la région des neiges éternelles, ou qu'on s'enfonce dans les abîmes des mers, d'où résultent les changemens progressifs de la végétation à diverses hauteurs. Lorsqu'on voit tant de résultats obtenus par *le seul secours d'un peu de mercure enfermé dans un tube de verre*, et qu'on songe *qu'on petit morceau de fer, suspendu sur un pivot*, a fait découvrir la Nouveau-Monde, on conçoit *que rien de ce qui peut agrandir et perfectionner les sens de l'homme, ne doit être d'une légère considération.*" *Biot—Traité de Physique*, tom. i. pa. 62.

says Lord Bacon, "have entered into a desire of learning and knowledge, some upon an inbred and restless *curiosity;* others for *ornament* and *reputation;* others for *contradiction* and victory in dispute; others for *lucre* and living; *few* to improve the gift of reason given them from God, to the benefit and use of men. As if there were sought in knowledge, a *couch*, whereupon to ease a restless and searching spirit; or a *terrace* for a wandering and variable mind to walk up and down in, at liberty unrestrained; or some lofty tower of state, from which a proud and ambitious mind may have a prospect; or a *fort* and commanding ground for strife and contention; or a *shop* for profit and sale; and not rather a rich *storehouse* for the glory of the Creator of all things, and the relief of man's estate."*

Rest not, then, till you acquire a capacity of rising spontaneously, from the contemplation of the sublime in matter, to that of THE SUBLIMEST in mind;—to that of the SUPREME REALITY, who comprehends all which he has made, and infinitely more than what, as yet, delights and interests us, within the scope of one grand administration;—to Him whose ineffable character "*gathers splendour from all that is fair, subordinates to itself all that is great, and sits enthroned on the riches of the Universe!*"

* Bacon's Advancement of Learning, lib. i. ch. 5.

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